

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

San Jose Scale

BY L. CAESAR.

SUMMARY OF CONTENTS

The original home of the San José Scale is China. It was unwittingly introduced into San José, California, about 1870. By 1893 or 1894 it had spread all over most of the United States and had even been brought into Ontario. Shipments of infested nursery stock were the chief means of its distribution. In Ontario there is believed to be no scale at present north of a line drawn from about Sarnia to Toronto, and more than half of the territory south of this is still free. The scale will probably live and thrive wherever peaches will live and bear some fruit, even though not in a commercial way. It is likely to spread into all such districts, and possibly farther.

All orchard trees, except sour cherries and usually Kieffer pears, are attacked. Currants and rose bushes, mountain ash and hawthorn, and a few other trees and shrubs are also severely affected.

The easiest way to identify the scale is to become familiar with the adult female and the immature black stage, and to know that the insect usually causes small, circular, reddish spots on the fruit and a purplish discoloration of the tissues beneath the bark where it feeds. The adult female is almost circular, nearly flat, about 1-16 of an inch in diameter, grayish to ashy brown in color, with usually a small yellowish central area. The immature black stage is found at all seasons of the year and is very small, a mere dot, black, circular, with a nipple in the centre, around which is a depressed ring or groove.

The first brood of young scales begins to appear about June 20th. There are probably three, or nearly three, full broods a year in Ontario, and young active larvae may be seen up to the severe frosts about the end of October. So prolific is the insect that we may have at least 1,000,000 offspring from a single over-wintered female. It is this enormous power of reproduction that causes San José scale to be destructive.

Parts of a tree above ground are subject to attack. Young trees may be killed in two years, older trees take longer. Orchards not sprayed will, if infested, be destroyed by the insect.

There are a number of native foes that attack it, but up to the present they are of little importance in Ontario.

The insect can be readily controlled by a single thorough spraying once a year before the buds have burst in spring. Badly infested trees should always be sprayed twice the first year. Old apple trees must be well pruned and the rough bark removed to secure satisfactory results.

The spraying must be very thoroughly done, so that every part of the tree from the ground up is covered. It should not be done when the bark is wet or the temperature is below freezing point.

This spraying would pay even if there were no scale, and our best apple growers regularly apply it along with two or more later applications to keep their orchards healthy and the fruit clean.

Lime-sulphur is the best and cheapest well-tested remedy.

It is usually possible to control the scale in one's own orchard independently of neighbors.

All nurseries to-day are inspected, and infested trees broken down and burned. No nurseryman is permitted to sell nursery stock without its being first fumigated with hydrocyanic acid gas.



Fig. 1. An old neglected apple orchard nearly killed by San José Scale. Observe the numerous leafless dead branches. (Original.)

SAN JOSÉ SCALE.

(*Aspidiotus perniciosus*, Comstock.)

INTRODUCTORY.—With the renewed interest of the last few years in fruit growing, and especially in apple growing and in the renovation of old apple orchards, has come a new interest in the different insect pests and diseases of the orchard. Of these foes the most destructive, wherever it occurs and is able to thrive, is the San José (pronounced Sān Hō zay, or Sān Hō say) Scale. This insect infests only a small part of the Province, but a part that is admirably adapted for fruit growing, hence the importance to the orchardists in these districts of being well informed on the means of identification, habits and best methods of controlling this pest. Interest, however, in the San José Scale is by no means limited to the infested areas, because progressive fruit growers in other parts of the Province, having heard or read reports of its destructiveness elsewhere, are anxious lest it get

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established in their locality. Consequently the demand for information is already large and increasing. To satisfy this demand so far as possible is the purpose of this bulletin. In preparing it the writer has not depended solely on his own investigations and the experience and observations of others in this Province, but has freely consulted the publications of various investigators elsewhere, who have made a careful study of the life history and control of the insect. The chief works thus consulted are the various publications of the Bureau of Entomology at Washington, D.C., and of the Experimental Stations of New York, Illinois, Ohio, New Jersey, Georgia and Tennessee.

BRIEF HISTORY.—The native home of the scale has been discovered by Dr. Marlatt to be in China. In 1873 it was first discovered in North America at San José in California. From here it was unwittingly shipped on nursery stock to nurseries in the Eastern States, and infested shipments from these in turn spread it widely. By 1894 it had become established in most of the Eastern States and in many of the Middle and Pacific ones as well. In 1897 it was found in Ontario, in Kent and Essex Counties, and also near St. Catharines and Niagara-on-the-Lake, but the large number of infested trees showed that it must have been introduced about 1893 or 1894, and so has been approximately twenty years in this Province. It was doubtless brought in on nursery stock. So far as I can discover, Ontario is the only Province in Canada where it has become established. It has twice been found in moderate numbers in British Columbia, but I am told by the Provincial Horticulturist and one of his assistants, and also by Mr. Treherne, the local Dominion Entomologist, that it has been exterminated, or at any rate has not been seen for several years. It has also been introduced into Nova Scotia, but infested trees have been destroyed, and there is good reason for believing that it has not obtained a foothold.

PREVALENCE AND DISTRIBUTION IN ONTARIO.

The map gives a fairly accurate outline of the districts where the scale is found. A good deal of time has been devoted to getting the data on which the map is based. Not only were all records of places from which the scale was sent in in the past considered, but the co-operation of the district representative in each county was gained. As these men know their respective counties well, and are greatly interested in all that in any way affects the farmers, their assistance was invaluable. In addition to this Mr. Jas. Neilson, a student of the Agricultural College, Guelph, devoted five months this summer under my direction to the sole task of determining the northern limits to which the scale had spread.

It will be seen that a line drawn from about Sarnia to Toronto marks the present northernmost limit of the scale. A study of the counties south of this line shows that Kent, Essex, Elgin, Welland and Lincoln are the worst infested counties. In Lambton the lower third has considerable scale, and there are a few isolated places farther north, as high or a little higher than Sarnia, where it is found. The southwest corner of Middlesex contains badly infested orchards, and there are also two or three affected orchards about five miles from London. In Oxford there was one badly infested orchard about four miles north-west of Woodstock. (The orchard has been sprayed this year and nearly all the scale destroyed). This seems to have been the only infested locality in this county. In Norfolk there are five localities where the scale has been found. In Brant there is an outbreak near St. George, but apparently only a very limited area is affected. In Haldimand there is considerable scale in the district along the lake, and though we have no reports of



Map showing the present distribution of San José Scale in Ontario. Areas darkened by close oblique lines are worst infested; those with lines farther apart are lightly affected, not every orchard being attacked. The small dark squares or rectangles indicate isolated infested localities in otherwise scale-free counties.

its being found elsewhere in the county it is probable that more careful search would reveal its presence to a slight extent in several other localities. In Wentworth all the section between the so-called "Mountain" and the lake is more or less infested, but we have no proof that it has yet spread beyond this district up into the higher land. In Halton there is a small area of about two miles square close to Burlington lightly infested. In Peel a few trees in one orchard at Dixie are somewhat badly attacked.

In the great fruit districts north of Lake Ontario and around Georgian Bay no trace of living scale could be found. It can easily be seen therefore that only a small portion of the Province is affected at present.

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Readers of course should not make the mistake of supposing that every orchard in the darkened area is badly infested. The fact is that this area includes nearly all of the tender fruit belt, and it is only in the neglected or semi-cared for orchards that the scale is found doing any injury. The well-cared for orchards are clean, and it is with difficulty that any scale can be found in them. In Kent and Essex, however, and in parts of Elgin, Welland and Lincoln there are hundreds of apple orchards that have been killed by it and hundreds more that will soon be killed. The owners of these orchards are not trying to save them, largely because they have not yet learned how valuable an asset an old apple orchard may be made.

THE EFFECT OF CLIMATE IN LIMITING SPREAD.—Since the San José scale is to-day, as shown in the map, confined to the south-western part of the Province, which is also the warmest part, it is very natural that the question should arise whether it can thrive in the other parts or is ever likely to do much damage to the fruit industry there. There is not sufficient data to give a definite answer to this question, but in my opinion there is very little doubt that the insect can live and thrive at least wherever peach trees can be grown. We may therefore expect that it will gradually spread through all the peach districts, including the district around Forest and the southern part of Lake Huron. At Collingwood at the base of the mountain, a well sheltered locality, I have seen peach trees that were about twenty years of age. I feel satisfied that if the scale got established there it would be able to do considerable damage. Furthermore in many parts of the Province we find here and there in back yards in towns a peach tree flourishing and bearing fruit. In such sheltered places I should expect the scale could become destructive. But apart from these cases in the great fruit districts where peaches cannot grow in the open we have considerable reason to hope that time will prove that the scale will not flourish or do much harm, though once introduced it may be able to maintain a struggling existence for years. While such is my hope, my advice to everybody is: *Take no chances, and on the least suspicion of its presence do your best to eradicate it.*

A brief review of the reasons for hoping that this pest may not be able to flourish much farther north than its present limits will be of interest:—

(1) The insect has now been in Ontario for about twenty years. In the course of this time it can scarcely be doubted that live scale has many times been shipped on nursery stock into such districts as the flourishing commercial apple-growing counties north of Lake Ontario; in fact I myself know of three cases where it has been found during the last five years on young trees in these districts, and yet has never got established. I am not sure whether the owners destroyed all these trees, but in any case there must have been similar occurrences where the trees were not destroyed.

(2) From correspondence with entomologists in the northern parts of the United States, where climatic conditions may be found approximating to those of our own uninfested fruit districts, I have received the following information:—

In New Hampshire the insect's present northern limits are Wolfeboro' and Plymouth, latitude about 43° 40'. In this State Prof. O'Kane says: "In general, in New Hampshire it is so far troublesome largely in the neighborhood of cities, although we are getting occasional reports of it from orchards, and in some cases severe damage is recorded." It seems evident from this statement that it is not regarded as doing a great deal of damage in New Hampshire, and does not occur at all in the northern part of the state.

In Vermont, Mr. Harold L. Bailey, Assistant Entomologist in charge of insect suppression, states that the northernmost infestation consists of two orchards in the Champlain Valley which supposedly became infested from nursery stock in 1901. These orchards have not been rayed except spasmodically until this year. Mr. Bailey says: "The fact that the insect has not apparently spread to any trees outside the orchards into which it was originally brought seems to show that no rapid spread is to be looked for in this district." He states that in the lower and thus warmer part of the state it is spreading much more rapidly.

In New York some of the fruit-growing districts are badly infested with scale, but Dr. Felt, the state entomologist, says that in some of the colder parts the scale seems unable to make any headway. One colony at Lebanon Springs that was apparently thriving ten years ago has practically disappeared to-day.

In Minnesota, Prof. Washburn states: "It evidently cannot survive our severe winters." He has tried rearing it out of doors, but after a few years it perished.

In Michigan, Prof. Pettit tells me that conditions are approximately the same as in Ontario. The scale is abundant in the warmer districts corresponding to our badly infested counties, but outside of these is rarely found. He says: "My belief is that the scale will grow almost anywhere, where peaches will fruit, but that it will not stand a colder climate than that required for peaches. This does not mean that peaches will grow successfully in a commercial way, but where they will grow some kind of fruit that can be called a peach."

In Idaho, Prof. Aldrich has given a good deal of attention to the effect of climate upon the scale, and has described to me a very interesting case. He says there is a valley situated about 700 feet above sea level. The land to the north of this rises up rapidly, and at a distance of three miles the average elevation of the country is about 2,600 feet. This height is maintained for at least 30 miles back. In the valley tender fruits flourish; on the heights the hardier fruits. In the valley the San José scale has thriven for 25 years; on the high land it has never been able in all that time to become established.

Dr. Aldrich is inclined to think that it is not the occasional dropping of the thermometer in winter to a very low point that is the important factor in determining the natural control of the scale in a locality, but rather the total number of hours during the summer when the temperature is above 80° or perhaps even 90°F. In the valley referred to, in which the town of Lewiston is situated, he says he feels sure that there are five times as many hours of maximum temperature from 80° to 90°F or upwards, as at Moscow on the higher land thirty miles away. By "optimum" temperature is meant the temperature at which the scale thrives best and reproduces most rapidly.

(3) By reading Dr. Marlatt's account of the distribution of the scale in 1906 as given in bulletin 63 of the Bureau of Entomology, Washington, D.C., and comparing this with the present distribution in the northern states and Ontario, one sees that since that date the pest has spread northwards only to a very limited extent.

(4) In the northern districts there is a gradual lengthening of the winter, and also a longer period of humid, wet, alternately freezing and thawing weather in spring and fall, both of which have an unfavorable effect upon the scale. Now we know that ordinarily less than 50 per cent. of the scales come through the winter alive even in the Niagara district; we should look therefore for a much smaller percentage in a climate like Guelph, and a still smaller in colder and more moist

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climates. Again between Guelph and the Niagara district the difference in climate is sufficient to lessen the length of the breeding season by about a month, so that this factor along with the greatly lessened number of days of optimum temperature and the other facts mentioned above all lead to the hope that most of the parts not infested to-day in Ontario will remain free. Time alone, however, will tell whether this hope will be verified, and until we are certain the best course is as I have said above, to "Take no chances."

PLANTS ATTACKED BY SAN JOSÉ SCALE.

We have found the scale attacking the following orchard trees and shrubs severely: *Apple, crab, pear, plum (both European and Japanese), peach, sweet cherry, red currant and black currant*. It very seldom attacks sour cherry; in fact we have never found it on any of the sour cherry varieties. Kieffer pears, though occasionally attacked, are seldom much infested even when near other trees badly attacked. Quince, apricot and gooseberry in our experience are not commonly or severely attacked, though it is very probable that we may find exceptions in the future, as some writers include these among the severely or commonly infested plants. Of apple trees, the Spy, though by no means immune, seems usually to be less severely attacked than most other varieties.

In addition to the above plants we have found the scale on the following ornamentals or forest trees and shrubs: *Mountain ash, hawthorn, Japanese quince, Japanese flowering crab, rose, wild red cherry or pin cherry, American elm, European elm, dogwood (Cornus alternifolia and C. siberica), willow (Salix vitellina), poplar (species not certain, but probably Carolina poplar (Populus deltoides), junberry, lilac, sumach (Rhus typhina), Japanese walnut and honey locust (Gleditsia triacanthos)*. The first four of these plants are often very severely attacked, and sometimes killed. The elms, when small, may be destroyed; but once they have become fifteen feet or more in height the scale does not seem to be able to kill them, though it may cause some of the smaller branches to die.

Dr. W. E. Britton* in his carefully compiled list of plants commonly attacked by the scale includes the following additional Ontario trees and shrubs: *Chokecherry, Lombardy poplar, flowering currant (Ribes aureum), osage orange and several species of willow*.

San José Scale may also be found in very limited numbers on almost any tree that is close beside or beneath badly infested trees; for instance I have found it on the following young trees: *maples of several kinds, catalpa, birch, oak, tulip, basswood and horse chestnut, situated alongside very badly infested pears and plums, but it is doubtful whether it winters on such trees*.

The above lists of ornamental and forest trees and shrubs might give the impression that our forests are likely to harbor the scale in great numbers and so become a dangerous source of infestation, but this does not seem to be the case. We find that scale-infested trees are usually situated in the orchard or else along the roadside, in fence corners or on lawns, and, while susceptible species of the outer trees of a forest bordering on an infested orchard may be attacked, there is usually little danger from the forest trees as a whole.

*Report of the Connecticut Agricultural Experimental Station, 1903, Part II., second report of the Entomologist, pp. 122-123.

HOW TO IDENTIFY THE SAN JOSÉ SCALE.

APPEARANCE OF THE SAN JOSÉ SCALE.—If we take a San José Scale infested piece of bark or an infested apple or pear in the summer or early autumn and examine it carefully we shall find the surface studded with small dot-like bodies. If we crush these, juice or fat will run out from beneath, and if we use a pin or a knife we can easily remove them from the bark or the skin of the fruit. These little dot-like bodies or specks are scales. Now if we examine them more closely with a hand lens we shall see that there are a few circular scales several times larger than any of the others. These are the adult female scales, and they are usually grayish or grayish-brown in color. Further study will reveal a good many elongate or oblong scales about twice as long as broad, and usually grayish or blackish in color. These are the adult males. Examining those that are left we shall find large numbers of little black scales about half the size of the males but quite circular. These are a very important stage of the immature females and males, because it is in this stage that all, or practically all, the San José scale winters, and by them we usually identify the insect. In addition to these three forms we shall find, especially on warm days, numerous little orange yellow scales running about. These are the larvae, both

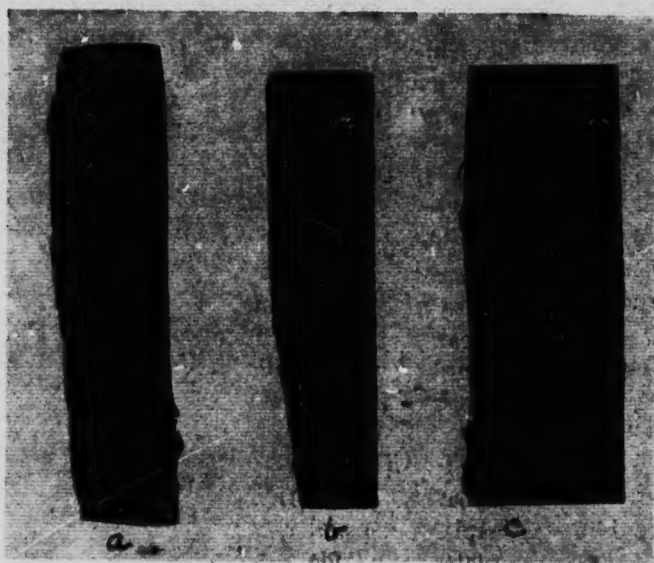


Fig. 2. (a) A healthy piece of apple bark showing the natural smooth surface. (b) A badly infested piece with the bark completely covered by the scale. This piece has an ashy appearance. (c) A similar piece of bark to b, but showing the small circular areas from which dead adult female scales have dropped off. Natural size. (Original.)

males and females. It is only while in this stage that females can move about. Intermediate between these active little yellow larvae and the small black circular stage will be seen little white dots, which are the young larvae that have just settled down and covered themselves over with their first waxy coat. As this covering thickens and hardens it gradually becomes darker, until the black stage mentioned above is produced, so that we shall find many very small scales varying in color between white and black. Of course, what we see with the naked eye, with the exception of the little active yellow larvae, is not the insects themselves, but merely

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the covering or scale that protects them. To see the insect itself, take a pin or the point of a knife and gently lift the scale, and underneath will be found a pear-shaped, fat, yellow, helpless body, the real insect, with no legs or eyes in the case of the females, but only a long sucking tube beneath its body projecting into the bark or tissues of the fruit beneath. (See Fig. 4.)

DESCRIPTION OF THE SCALE IN MORE DETAIL.—Now that we have given a general description of the various stages of the scale found in summer, let us consider more carefully the three most important stages for identification, namely, the adult female, adult male and the black or winter stage.

(a) *Adult female Scale.* (See Fig. 3A):—Shape circular or almost circular, nearly flat, being slightly raised towards the centre; size 1.2 to 2.0 mm. in diameter, average about 1.5 mm. (about 1-16 of an inch); general color grayish or ashy brown, with a lighter colored central area from 1-4 to 1-5 of the total diameter in

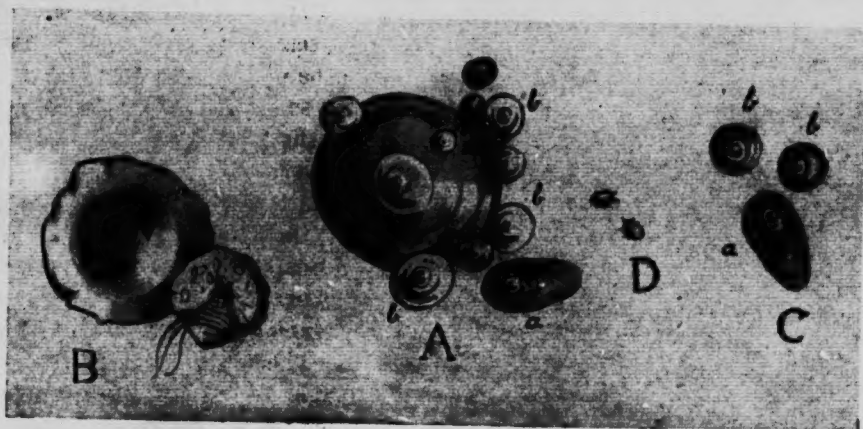


Fig. 3. Various stages of San José Scale, all enlarged about fifteen times: A: Adult female scale with immature young of various stages settled down around or upon it; a, an adult male scale; b, b, b, three small black scales, winter stage. B: An adult female scale turned over, revealing the insect herself beneath with bristle-like mouth parts exposed. C: a, an adult male scale; b, b, two immature black winter scales. D: Young active larvae soon after birth. Note the nipples and little grooves around them in A b, b, b, and in C b, b. (B redrawn from Alwood, the remainder original drawings by Miss A. Hearle.)

width. This lighter area varies in color from a dirty white to yellowish-brown or yellow, and if very carefully examined with a good hand lens will usually be seen to consist of two portions: First an outer belt occupying a little more than half the space and an inner area usually a little more elevated than the outer, and with a tiny knob or nipple in the centre. Sometimes, but by no means always, a little depressed ring or groove can be seen around this nipple. Occasionally a black fungus growth conceals this central area, or a thin waxy film may entirely or partly cover it, but if these are gently rubbed off the normal color will be found beneath.

(b) *Adult male.* (See Fig. 3C a):—Shape irregularly oval or elliptical, about twice as long as broad; length, about half the total diameter of the adult female; width, as implied, about half the length. Adult male scales are therefore very much smaller than the adult females, not being more than 1-5 the size. The general color varies from a light gray or grayish-brown to black. Near one end is a circular area, in the centre of which is to be seen a little knob or nipple which often, but not

always, has a tiny depressed ring or groove around it. This circular area is easily seen with a hand lens, and is commonly yellowish in color, though sometimes black.

(c) *The Black or Winter Stage.* (See Fig. 3A 'bb') :—At this stage the scale is very small, looking to the naked eye like a tiny black speck. A hand lens is absolutely necessary to make out any of the details. An examination of fig. 3A b shows that it is circular, flattened, not more than 1-10 the size of an adult female, and about half the size of the male. It has a little nipple in the centre surrounded by a depressed ring or groove. The nipple and depressed ring around it, along with the black color, are the most important characteristics to remember. Sometimes the color varies a little and the nipple may be whitish, frequently the outer margin of the ring is whitish, but usually in Ontario every part of this stage is black. As said above, this is practically the only stage in which the insects pass the winter. Of course adult females and very young scales are to be found in early winter, but they apparently all die.

OTHER SCALE INSECTS ALLIED TO AND SO CLOSELY RESEMBLING SAN JOSÉ THAT THEY ARE OFTEN MISTAKEN FOR IT.—Such scales as the Oyster Shell, Scurfy and European Fruit Lecanium, or, as it used to be called, New York Plum Scale, are so much larger, especially the last named, and so different in shape that no one who has read the above account and examined the figures could for a moment mistake any of them for San José. There are, however, in Ontario probably a dozen scales belonging to the same genus (*Aspidiotus*) as the San José, but only four of these are at all commonly found. These are: 1st, the European Fruit Scale, or, as many of us are accustomed to call it, the Curtis Scale (*Aspidiotus ostreaeformis*); 2nd, the English Walnut Scale (*Aspidiotus juglans-regiae*); 3rd, the Putnam Scale (*Aspidiotus ancylus*), and 4th, the Cherry Scale (*Aspidiotus forbesi*). None of these scales are very destructive in Ontario orchards. The first of these, the European Fruit Scale or Curtis Scale, is common on apple trees, especially on the very large branches where it may often be found under the loose bark, though it by no means always feeds under shelter. It is the only one of these four that I know of that is ever found on the fruit. During the last two years I have seen several apples with these scales on them, and resembling so closely the San José scale that they would usually be mistaken for it. The resemblance is increased by this scale having the same power as the San José to cause a reddish discoloration of the fruit. The English Walnut Scale has not, I think, been found on fruit trees in Ontario, though in other places it does attack them. In St. Catharines it is very abundant on soft or white maple (*Acer saccharinum*). I have also had it sent in on poplar, and Prof. Jarvis has found it on willow. I find both it and the previous scale heavily parasitized. The Putnam and Cherry Scales are not very common, though they are occasionally sent in. They attack the bark of orchard trees and of a few other trees. I have never seen one on the fruit itself.

I had planned to add a key for the identification of these four species, but they vary so much with the different kinds of bark on which they are found, and at different times in the season, that no matter how carefully and accurately the key might be made there would always be the danger of mistakes; hence when in doubt the best way will be to send specimens for identification to the Department of Entomology, O.A.C., Guelph, or to the Dominion Entomologist, Central Experimental Farm, Ottawa. Many of the best students of scales find it necessary at times to clear the insect itself beneath the scale in certain solutions and then examine what is known as its anal plate under a compound microscope. A study of this part is the final test of its identity.

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HOW SAN JOSÉ MAY BE DISTINGUISHED FROM THE ABOVE SCALES.

If it is not advisable to try to show how the above four scales may be distinguished from one another, it is very important to give simple methods by which any person can tell if he finds one of these whether it is the San José Scale or not. The following points will enable him to do so:

(1) All five scales, if the surface is rubbed, will show a small nearly circular area quite different in color from the rest of the scale. This area we shall call the *exuviae*, because it is due to the moulted skins (*exuviae*) of the insect having become worked into the covering scale and showing through it. In the San José scale the *exuviae* is situated in, or almost in, the centre of the scale, and is yellowish. In most of the other four scales it is situated a little to one side of the centre, and is either some shade of red or orange, being very rarely yellowish. Frequently it is covered over by a film which conceals it unless first rubbed gently. The color and position of the *exuviae* are therefore very helpful distinguishing characteristics.

(2) Among the adult males and females of the San José Scale are always to be found a very large percentage of small black scales, each with a little nipple in the centre and groove around it. This has been already described, and mentioned as being also the wintering stage of this scale. If none of these small black scales are to be found the insects are not San José, or if some are present that, roughly speaking, answer to this description but are not black they are not San José.

(3) Look for the adult female scales, and if these though circular are more than 2 mm. about 1-12 of an inch) in diameter the scale is not San José, because the adult female of this is never more than 2 mm., and is usually about 1.5 mm. or 1-16 of an inch in diameter, whereas the adult female of the English Walnut Scale (*Aspidiotus juglans-regiae*) is 3 mm., or nearly $\frac{1}{8}$ of an inch in diameter. The other three species are smaller than it, and nearer the size of San José.

(4) If the scale occurs in abundance on the fruit and causes red spots on it, or if it often produces a reddish discoloration on young shoots, or if, when the bark of a badly infested branch is cut through obliquely, the tissues beneath are seen to be stained purple or reddish, the insect is almost certain to be San José Scale. It is true that the Curtis Scale and also the Scurfy Scale will produce red spots on the fruit, but they are very seldom found on it. Moreover the Scurfy Scale is not circular and does not resemble the San José closely.

These points, along with a careful study of the description given above and of the accompanying illustrations, should make the identification of San José Scale comparatively easy.

A RED SPOTTING OF FRUIT NOT CAUSED BY SAN JOSÉ SCALE.—Frequently one sees various kinds of apples in autumn with tiny red spots on the surface. Bell-flowers are very subject to this. At first glance these spots are very suggestive of San José Scale, but on a close examination with a magnifying glass it is easy to discover that they are due to some other cause, probably some species of fungus. If they had been caused by any scale insect either this would be present and could be lifted up with the point of a knife blade or with a pin or it would leave a light-colored central area showing that it had been removed by something. The spots referred to above, however, are darkest in the centre, and in this darkest part the epidermis is usually ruptured as if by a fungus growth.

LIFE HISTORY.

The insects, as already mentioned above, pass the winter in the small black circular immature stage. In this stage both males and females are alike. After the warm weather comes in the spring the male scales begin to elongate until they become oblong, and as described on page 9. (See Fig. 3Ca.) Towards the latter part of May (this year May 20th or 21st), the living insects beneath the scale covers have become winged, and back out from beneath the cover. Fig. 5 shows the appearance of one of these male adults, but is of course much enlarged, since the insect itself is so small that it can only with difficulty be seen without the aid of a hand lens. The general color of the body is orange. There are only two wings each with two veins in it. The antennae are long and conspicuous, and, projecting from the end of the body, is a long style, which makes it very easy to distinguish the male from tiny parasites or other small insects. (Any winged parasites that might be found would have four wings instead of two.) Soon after emerg-



Fig. 4. Full-grown female from beneath scale, showing the very long sucking tube, composed of several tiny bristles; greatly enlarged. (After Howard and Marlatt.)

ence the males move around in search of the females. The latter then begin to increase in size, and towards the middle of June have reached the size and appearance described on page 9. (See also fig. 3A.) They now begin to give birth to living young, no eggs being laid by this species, contrary to what we find in the case of most other scales, even very closely allied species. Each female produces several young a day, and may continue to do this for 40 or 50 days, so that the total number of young from each may be over 400. (At St. Catharines young larvae began to appear this year on June 25th, and last year, 1912, on July 1st. June 20th is probably about the average date). For a few hours after birth the young larvae remain by the mother insect under the protection of her covering scale, and can easily be seen by lifting this up. They then come out and run around actively for an average of about 24 hours. During this time they may have travelled several feet from the mother insect, but more frequently the distance is only a few inches, and not uncommonly if they have moved away at all they return to her again. At the end of about twenty-four hours they insert their little sucking beaks through the bark or the surface of the leaf or fruit on which they may happen

to be. Very often they settle on the margin of the mother scale and force their beaks right through her waxy covering. (See fig. 3A.)

The young larvae are very small, mere dots, of an orange-yellow color, oval in shape, with six legs, one pair of antennae, and two eyes. The most striking thing about them is the character and position of the mouth parts. These consist of a long thread or bristle-like sucking apparatus really composed of four very fine sharp little bristles fitting closely together, and arising from underneath the body. They can be seen in Fig. 6 as a little coiled thread. This beak is about three times as long as the body, and in the case of the full-grown scale reaches deep into the bark. It seems wonderful that such a delicate little structure can be forced through the hard bark of an apple or plum tree.

After settling down and inserting its sucking tube, the little insect begins to assume a circular form, and at the end of about a day becomes covered all over with delicate white wax, which is secreted through pores on its own body. Soon this becomes thicker, more compact and larger as the insect grows, and gradually



Fig. 5. Winged male, much enlarged.
(Redrawn from Alwood.)

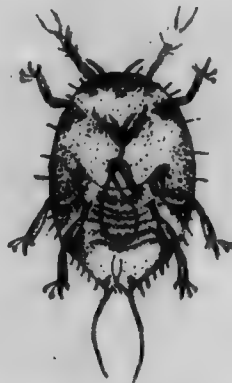


Fig. 6. Young active larva, ventral view,
much enlarged; natural size is a mere
speck. Redrawn from Alwood.)

the color changes until the black winter stage described on page 9 (see also Fig. 3Cbb) is reached.

Up to this time the external appearance of both males and females has been the same, but now they begin to differentiate, and in about two weeks more another brood of adult winged males appear which fertilize any females that are sexually mature. All the males do not of course emerge at the same time, nor are all the females sexually mature at once, because, as said above, a single adult female continues ordinarily to give birth to living young for forty days or longer; hence there will be a great overlapping and confusing of broods. From the time of birth to its emergence as a winged adult the male, according to Marlatt,* requires from 24 to 26 days. Our observations would lead us to believe that this year in Ontario 30 days would be nearer the time. The hotter the climate the shorter the time would naturally be, and Marlatt's figures are for Washington, D.C. He also states that from the time of birth to the production of young by the female requires in

*See Bulletin 62, page 47, U. S. Bureau of Entomology.

summer from 28 to 49 days. Here again with us the period seemed to be about ten days or more longer.

At Washington it was found that there were four full broods and a possible partial fifth, but as the males emerged early in April, and in Ontario not until about May 20th, a month or more later, we should not expect so many broods. It was not part of my original plan to attempt to work out the life history or number of broods. However, my assistant, Mr. G. J. Spencer, and I by placing a definite number of the earliest larvae on each of several uninfested nursery trees secured for the purpose were able to make some valuable observations. As a result of these I am of the opinion that we have not more than three broods, and probably the third is not quite a full one. To be absolutely certain on this point would require a good deal more work with great care to see that natural outside conditions were observed. Our rearing was done outside, but under cheesecloth, and in the city of St. Catharines.

Whatever the number of broods, running larvae may be seen in warm days as late as November. I found a few this year on November 4th in the Niagara district.

ESTIMATE OF THE NUMBER OF OFFSPRING IN A YEAR FROM A SINGLE OVER-WINTERING FEMALE.—It is estimated that each female may on an average produce 400 or more offspring; approximately half of these may be males. Now if we suppose, as I think is correct, that we have not more than three generations, the total number of offspring at this rate from a single adult, if all lived, would be 16,000,000, and if we estimate the number of generations at two and one-half it would be 8,000,000. If we allow for a total mortality of 50 per cent. in each generation we shall still have at least 2,000,000 if there are three full broods, and 1,000,000 if there are only two and a half. It is because of this marvellous power of reproduction that the San José Scale, though such a tiny creature, is so destructive. None of our other species of native scales can increase at anything like this rate, the highest probably being not faster than an average of 1,000 from a single female in a season.

MEANS OF DISTRIBUTION.

By far the most important of all the various means of distribution of the San José Scale from one district to another has been infested nursery stock. In this way it has been carried from California to the Eastern States, Canada, and to several other portions of the world. Once in a locality, it spreads from tree to tree and orchard to orchard by the little active larvae crawling upon various kinds of insects or birds that alight upon or frequent infested trees and then go to some other tree either near by or at considerable distance. As active larvae abound on infested trees from the end of June to the severe frosts, it is quite evident that they are also carried on the hands, clothes, baskets or ladders of the pickers, or even on the horses or vehicles used in the orchard gathering the fruit or for any other purpose. Where trees are close together the larvae travel from branch to branch, or may be carried by the wind a short distance from a higher branch of one tree to a lower one of the neighboring tree. Many of the inspectors of nursery stock believe that the wind plays an important part in infesting stock situated near large, badly attacked trees. Just how far the scale may be carried in this way I cannot say definitely. In a moderate breeze I have caught them on tanglefoot placed near the ground six feet away from a branch about 15 feet high. I should not be at all astonished if strong gales would carry them occasionally as far as 30 or 40

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fect from the top of tall trees. They do not cling very tenaciously to the part they are on, and many drop off. Rains doubtless wash them from higher to lower branches. To spread through an orchard of, say, ten acres until every tree is clearly infested will sometimes require two or three years, and apparently depends largely upon what part of the orchard became first infested and how well the scale thrives in the district.

Many fears have been expressed that the scale will get established in new centres through marketing infested apples, which may be shipped to various parts of the Province. There is apparently very little danger from this in the case of winter fruit, which is packed late, and from which active young getting on trees would scarcely have time to become sufficiently advanced to stand the winter. In the case, however, of fruit marketed earlier in the season, it is more reasonable to fear that the insects might get a foothold. Ever since the San José Scale was discovered to be a very serious pest entomologists have thought of this possibility, but it is very encouraging to learn that in no case up to the present is there any



Fig. 7. San José Scale on apple, showing both the scales themselves and discoloration caused by them, natural size. (Original.)

known recorded proof that the marketing of infested fruit has resulted in the establishment of new colonies. Nevertheless, as a wise precaution, the sale of such fruit is forbidden by law, and any person found selling or offering it for sale is liable to a penalty of not less than \$10 nor more than \$100.

INJURY TO PLANT LIFE.

PARTS OF THE PLANTS ATTACKED AND NATURE OF THE INJURY.—The scale will attack any part of the tree or plant above ground—trunk, branches, twigs, leaves, leaf-stems, fruit and fruit-stems. Small trees are usually attacked nearly uniformly all over, except that the leaves are not so badly infested. Large apple trees are worst attacked on the outer branches and twigs, the coarse, thick bark of the trunk and large branches having fewer scales on it probably because more

difficult to pierce with their delicate little beaks. A badly infested tree or branch will become so thickly encrusted with the insects that the bark is completely concealed. (See Fig. 2.) Such branches look as if they were covered with ashes. If we cut through the bark obliquely we shall see that the tissue beneath even as far as the outer sapwood is conspicuously colored purple. On young branches and nursery stock there is frequently, but not always, a reddish area around where the scale feeds. This helps the inspector to find the insect more easily. The skin of the fruit, especially of apples and pears, is also conspicuously marked with these red discolorations, which often make it easy to detect the presence of the scale even without looking at the bark. On apples the insects are regularly most numerous in the calyx and stem ends, probably because these are more sheltered parts. Leaves, though not so commonly attacked as fruit and bark, are often badly infested,



Fig. 2. San José Scale on pear leaves and discolorations caused thereby, natural size (after Lowe and Parrot).

especially on the upper surface. The insect causes these also to become discolored. (See Fig. 8.)

The injury done by San José Scale is caused by the millions, or more correctly billions, of the little creatures sucking the juice out of the plant through their long, delicate beaks, and thus starving the tree by depriving it of its food. It is claimed that they also secrete a poison which increases the injury. Small trees may be killed in a couple of years; larger trees usually take longer, and an old apple tree may survive for six years or more, but ultimately will perish if not treated. The same fate will befall any orchard once attacked and left unsprayed. In old trees it is the outer branches that die first, and in putting a tree into shape to spray one often finds it necessary to cut such branches back six feet or more to reach the living parts. Infested fruit is usually dwarfed, and frequently there are small depressions where the scale feeds, especially in the case of pears. Such fruit is often almost worthless except to feed to stock, as it is illegal to sell it.

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It is clear, therefore, that if not kept under control there is no more destructive enemy to fruit trees than the San José Scale.

NATURAL ENEMIES.—Many of our scale insects are to a very considerable extent kept in check by predaceous enemies and parasites, but this is not true of the San José Scale. Its chief enemies are as follows:—(1) A very tiny, glossy-black ladybird beetle, *Microweisea* (*Pentilia*), *micella* and its brown larvae. (See Fig. 9.) A considerable number of these were found on most of the trees examined, but they were never numerous enough anywhere to control the scale even on a single branch. (2) A much larger black ladybird beetle with two red spots on its back, *Chilocorus bivulnerus*. This is a common insect in Ontario, but was very rarely found feeding on San José Scale. (3) Four-winged hymenopterous parasites (see Fig. 10.) Two species of these *Aphelinus mytilaspidis* and *Aphelinus fuscipennis* were reared a few years ago by Mr. Alfred Eastham, a graduate of the Agricultural College, but a careful examination of several orchards showed very few scales with little circular holes in them indicating that a parasite of this nature had emerged. (4) A large red mite that I have not yet had a chance to get identified. (5) A



Fig. 9. The Pitiful Ladybird Beetle and its larva (*Microweisea micella*), both much enlarged. The small lines show the natural size (redrawn from Marlatt).

fungus disease. This seems to be very rare. I have not myself seen it, but the late Dr. Fletcher reported it from the Niagara district.

From my own observations I think that all these enemies combined do not kill more than one scale out of one thousand. This, however, is not true of all parts of North America, for in some places disease or parasites or both are very helpful. In October Prof. Surface, of Pennsylvania, replying to a letter of mine said that the four-winged parasites there were becoming very abundant and doing a great deal to control the scale. He reported that there were many different species at work. It is my intention next year to bring in a good supply of parasitized material from Pennsylvania and try to establish these friends in our worst infested districts. Whether they will increase rapidly in our climate and become of much assistance is impossible to tell.

MEANS OF CONTROL.

In controlling San José Scale it is absolutely necessary to depend upon thorough spraying of infested orchards, but spraying is simplified and made less costly by certain preliminary steps. It should be borne in mind in treating neglected

orchards that the first year's work is far more difficult than that of any succeeding year. Once the scale is brought under control it is not very difficult to keep it there; in fact I consider it easier to combat successfully than the Codling Moth in the warmer parts of the Province.

TREATMENT OF ORCHARDS, ESPECIALLY OF OLD, NEGLECTED APPLE ORCHARDS, BEFORE SPRAYING.—Every orchard before it is sprayed should be carefully pruned to thin out any unnecessary branches and to remove dead or dying ones. This lets in the sunlight, allows the spray to reach every part more easily, and causes less waste. The trees are also healthier and bear better fruit.

Old, neglected apple orchards, however, require much more work to put them into shape for satisfactory spraying. They are often so tall and thick with branches that it is impossible to spray them thoroughly just as they are. Moreover the trunk and larger branches are covered with loose bark, under which the scale may be concealed and be untouched by the spray. Such trees should always have the branches well thinned out, and if tall, headed back to a reasonable height for convenient spraying. It is usually desirable to lower the tops considerably, sometimes



Fig. 10. *Prospalta aurantii*, a common parasite of the scale in some parts of North America, greatly enlarged (after Howard).

as much as eight feet or more. In doing this one should use judgment, and should try to make a well-balanced head. It is especially important in cutting back the upright branches to cut close to a cross-branch, especially to one running in such a direction as to keep the centre of the tree from being too open. Open centres tend to favor sunscald on large branches and are also undesirable, because this part should, like the rest of the head, be bearing fruit; in fact it is the part best adapted, because receiving most sunlight, to bear the choicest fruit. Cutting close to cross branches is necessary, because if this is not done the stubs that are left will rot and cause the tree to become hollow and thus weakened. Large cuts should be painted with white-lead or coal tar.

Where the orchard is large and help scarce the pruning may be done in scale infested districts at any time after the leaves are off, and the work in this way be distributed over several months. I find long-handled pruners, about eight or ten feet long, very helpful in thinning out branches one inch or under in diameter. They cost from 80 cents to \$1. Good ladders also soon pay for themselves. All prunings should be burned before the end of May.

After the trees are pruned the rough bark should be scraped off the larger branches and trunk with a hoe. This will expose all the scale to the spray. It may be done at any time of the year before spraying, and does not need to be done again for several years.

SPRAYING.

WHEN AND HOW OFTEN TO SPRAY.—Unless a tree is badly infested, one thorough annual application of the right mixture at the proper strength applied



Fig. 11. An old neglected apple tree. Heavy pruning, lowering the top and scraping off the bark is necessary before this tree can be thoroughly and economically sprayed (original).

in spring just before the buds burst will satisfactorily control the scale, but badly infested trees should receive two applications the first year to make a thorough job. Even on these it is quite possible, especially if the weather is dry at the time of spraying and for a few days later, to control the scale completely with a single application; but only the most thorough sprayers succeed in doing so, especially in old apple orchards. One of these two applications may be given in late autumn soon after the leaves have nearly all fallen or at any time in the spring when the weather permits; the other should be done preferably just before or as the buds are bursting, because the mixture will thereby remain on much longer into the summer and have more value in destroying any young scale there may be; for these seem unable to settle down and thrive on bark coated with lime-sulphur.

Peach trees are an exception to this late spraying, because we want the one application to control the San José Scale and the Peach Leaf-curl at the same time, and to do this it is necessary to spray before the buds have begun to swell. If the spraying is delayed until these are ready to burst, and if the weather has been wet and cold, the Leaf-curl will not have been controlled.

Fall spraying instead of spring where only one application is to be given is advocated by some. Good results are usually obtained, but on the whole it is found



Fig. 12. How an old orchard very badly attacked by San José Scale had to be pruned to get rid of dead branches and put it into shape to save it (original).

better to spray in spring. Some writers have been advocating summer applications about July 1st or a little later for the scale. In my opinion, based on some tests made, the results do not justify the trouble and expense.

THE BEST MIXTURE TO USE.—The lime-sulphur wash is to-day recognized all over North America as much the safest, best and cheapest spray mixture to use against San José Scale. Oil washes of various kinds have often given good results, but they have also under certain weather conditions, which may occur any season, caused much injury to the trees. They are much dearer than the lime-sulphur, usually costing more than double as much. Moreover they have but little fungicidal value, whereas lime-sulphur is well known to be a very valuable fungicide. In badly infested old apple orchards the use of an oil wash, such as Scalecide or Target Brand or even Kerosene Emulsion containing about 25 per cent. kerosene, to supplement lime-sulphur for scale on the outer branches and twigs would be quite valuable, because the oily nature of these sprays enables them to spread better over the bark and get more easily into contact with any scales situated among the pubescence on the smaller branches where they are hard to reach with lime-sulphur. However, if orchardists remember the need of spraying these outer twigs very carefully on account of the pubescence they can get quite satisfactory results with the lime-sulphur alone.

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A new spray mixture manufactured by the Niagara Brand Spray Company, and known as Soluble Sulphur, promises to be a valuable wash for the scale. I used it this year, at the strength recommended on the containers, on nine large very badly infested old apple trees and one pear tree, and got good results from the one application—just as good as from the regular lime-sulphur. Soluble Sulphur is a yellowish-green powder, and is made by combining sulphur and certain compounds of soda at a very high temperature and then apparently grinding the dry compound into a powder after it is cold. It dissolves readily in water, and is therefore very convenient to ship, store and use. Its price at present is about the same as that of commercial lime-sulphur. It may be that if a rain followed soon after spraying it would not give so good results as lime-sulphur. This remains to be tested. The directions for use are given on the cans. The manufacturers claim that their mixture can be safely used as a substitute for lime-sulphur in all the



Fig. 12. The same trees photographed from a little farther to the right two months later, about July 20th (original).

regular orchard applications. Without further tests under different weather conditions I am not prepared to recommend it for summer use.

THE PROPER STRENGTH OF LIME-SULPHUR TO USE.—As it is very important to use sufficiently strong mixtures, and as the most common forms of lime-sulphur are the commercial and the home-made concentrated, and as the different barrels of these vary in strength, it is very important to test them with an hydrometer before using, and then reason out by rule how much to dilute each gallon to get the proper strength. Specific gravity hydrometers are the most convenient, and cost about 80 cents. From my own experience and that of others I think the most desirable strength is about 1.035 specific gravity. A full account of how to use the hydrometer is given in the Lime-Sulphur Bulletin, No. 198, pages 10 to 13, and also a less full one in the Spray Calendar. Briefly stated, the rule is:—Gently drop the hydrometer into the clear concentrated liquid of the barrel after all sediment has settled and the temperature is that of the surrounding air. Note the figure to which it sinks. Suppose this is 1.800 in one barrel and 1.280 in

another. Then to determine how much to dilute each of these to get a strength of 1.035 divide the last three figures of the 1.300 and 1.380, respectively, by 35, and this will give the total number of gallons which each gallon, respectively, will make. Thus $300 \div 35 = 8.57$, or approximately 8%, and $380 \div 35 = 10.86$. This means that each gallon of the strength of 1.300 must be diluted with water to 8% gal. to make a strength of 1.035, and each gal. of the strength of 1.380 to 10.86 gal. to give the same strength..

Those who wish to use the old home-boiled lime-sulphur, an excellent but troublesome spray to make and apply, should consult Bulletin 198, page 14.

FORMULA FOR KEROSENE EMULSION FOR USE ON SCALE.—A number of fruit-growers in the districts where there are oil wells have asked for a formula by which they could make use of crude petroleum against San José Scale. The following formula is taken from Circular No. 124, Bureau of Entomology, Washington, D.C.:

"Kerosene Emulsion (stock solution 66 per cent. oil). Kerosene emulsion is made after the following formula:—

Kerosene (coal oil, lamp oil)	gallons 2
Whale-oil soap or laundry soap (or 1 quart of soft soap)....	pound $\frac{1}{2}$
Water	gallon 1

Dissolve the soap in boiling water, then remove vessel from the fire. Immediately add the kerosene, and thoroughly agitate the mixture until a creamy solution results. The stock emulsion may be more conveniently made by pouring the mixture into the tank of a spray pump and pumping the liquid through the nozzle back into the tank for some minutes. The stock solution, if well made, will keep for some months, and is to be diluted before using. In order to make a 10 per cent. spray (the strength for trees in foliage), add to each one gallon of the stock solution about 5% gal. of water. For 20 and 25 per cent. emulsions (for use on dormant trees and plants), use, respectively, about $2\frac{1}{2}$ gallons and 1% gallons of water for each one gallon of stock emulsion. Agitate the mixture in all cases after adding the water. The preparation of the emulsion will be simplified by the use of naphtha soap. No heat will be required, as the kerosene will combine readily with the soap in water when thoroughly agitated. Of naphtha soap, however, double the quantity given in the above formula will be required, and soft or rain water should be used in making the emulsion. In regions where the water is "hard" this should first be broken with a little caustic potash or soda, such as common lye, before use for dilution, to prevent the soap from combining with the lime or magnesia present, thus liberating some of the kerosene; or rain water may be employed.

Crude Petroleum Emulsion. Crude petroleum emulsion may be prepared in identically the same way as described for kerosene emulsion, substituting crude petroleum for kerosene. The same dilutions for winter and summer spraying should be made as prescribed for kerosene emulsion, but it should be noted that for summer treatments of trees in foliage the kerosene emulsion is preferable, as it is less likely to cause injury.

I have not myself tested these emulsions, but would advise that they should be used only to supplement lime-sulphur in spring, especially on the outer branches and twigs of large apple trees. It is not safe to drench trees with any oil wash, particularly the trunks and large branches. Spraying should be stopped as soon as it is seen that the part is well covered, and before it begins to run. It is also safer to spray on a bright or windy day than in dark gloomy weather, because the

former permits the oils to evaporate more quickly. Crude petroleum alone is seldom safe to use. Many trees have been killed by it.

SOME POINTS TO REMEMBER ABOUT SPRAYING FOR SAN JOSÉ SCALE—(1) Do not spray when the trees are wet; this weakens the wash.

(2) Do not spray just before a rain, because the rain will rapidly wash the mixture off unless it has first become thoroughly dry.

(3) Do not spray when the thermometer is at or below freezing point. The mixture does not seem to get into contact with the insects so well as in warm weather.

(4) If possible start soon enough to finish by the time the buds are bursting. If not through then and the scale is abundant spray ahead at the regular strength until all the trees are done. Often no damage to leaves will follow, in any case the spray will do less injury than the scale.

(5) Test the strength of the lime-sulphur with a hydrometer; it is the only business-like way where concentrated lime-sulphur is used.

(6) Take advantage of the wind. A strong wind is often helpful, especially for large trees.

(7) Do not be stingy with the material. Cover every inch from the base of the trunk to the topmost twig. Remember a single female missed may mean 1,000,000 by the end of the season. It may take eight gallons or more for a large tree, but only thoroughness will pay.

(8) A good gasoline outfit is very much quicker and more satisfactory than a hand pump for large, old orchards, but good work can be done with a hand pump, too.

(9) Keep the spray machine in good repair, pump clean water through it every night and take off the nozzles to prevent their getting set. It will save much loss of time. A circular piece of leather three inches in diameter placed at the base of the nozzles will largely prevent the mixture running down the rod and wetting the hands.

(10) Use gloves to save the hands.

(11) Try to supervise all the spraying yourself, or put it in charge of your best man.

IS IT POSSIBLE FOR A MAN TO CONTROL THE SCALE IN HIS OWN ORCHARD INDEPENDENTLY OF HIS NEIGHBORS?—Wherever an orchard is some distance, say ten rods or more away from an infested orchard, it can be kept almost free from scale whether the infested orchard remains neglected or not. In the Niagara district most good growers would not care much whether their neighbor sprayed or not. They are aware, too, that if he does not spray the scale will soon kill his trees and so remove the menace. However, there are often cases where orchards are almost touching, and if the one on the west, the side of the prevailing wind (from other directions the danger is usually not quite so great) is composed of tall trees badly infested there is no doubt that the nearest row or two of the neighboring orchard, however well sprayed and cared for, will be more or less affected by this. Under these circumstances if a man cannot persuade his neighbor to control the scale he should appeal to the scale inspector, if there is one, or else ask permission to treat his neighbor's outer row at his own expense, if he thinks it worth while to do so.

INSPECTION.

SCALE INSPECTORS.—During the past season there have been several inquiries as to the appointment of inspectors, especially in townships where our survey of the orchards showed there was scale, though the owners of the orchards either did not previously know of it or were not aware that it was so serious a pest. Sec. 7, Clause 1, of *The Fruit Pest Act* reads: "The Council of any local municipality may, and upon the petition of twenty-five or more fruit-growers who are ratepayers shall, by by-law, appoint at least one inspector to enforce the provisions of this Act in the municipality, and fix the amount of remuneration, fees or charges he shall receive for the performance of his duties." The Department of Agriculture pays half the salary of these men and the municipality the other half. For further particulars write to the Department for a copy of the Act. It is clear therefore under what circumstances an inspector may be appointed. In many districts inspectors are very desirable and helpful, but not in all. To be a success the inspector must have public opinion behind him, and must be looked upon not as an intruder, but as a friend who is trying to improve the fruit industry. Men who will only spray because they are compelled will seldom have any success against the scale, because they will not spray thoroughly, and poor spraying is very little better than none. These men, as a rule, try to work up opposition to the inspector, and often succeed so well that next year the Council thinks it expedient to get a new man. Now a competent new man with plenty of backbone will not be easily secured, because he can readily see that if he tries to do his duty he, too, need not expect to be re-engaged the following year. It is difficult in the face of strong opposition for a local man to do his duty as inspector and enforce the law impartially. When he sees the task ahead of him he will usually resign. Under circumstances like these I should urge the men who are anxious to have the scale controlled in their district to try to show their neighbors by their own thorough and successful work not only that the scale can be controlled, but also that it will pay well to look after their orchards. To convince a man that a thing pays is the surest way to get him to do that thing and to do it well. In most counties there are district representatives, and these men, if their attention is called to it, are always willing and able to help in arousing an interest in any great question, such as the control of the San José Scale. They are sometimes able to take charge of an orchard in an infested district and show by actual demonstration how to bring it back to health and the bearing of large crops of good clean fruit.

INSPECTION OF NURSERIES AND FUMIGATION OF NURSERY STOCK.—Since the chief means of spreading San José Scale has been on nursery stock, and since there is always a possibility of some of the stock escaping fumigation where the nurseryman is careless and the inspector unable to guard against it, it has been found advisable to supplement the fumigation by a careful inspection of the growing stock itself in the nursery grounds. This year all saleable stock, over 4,000,000 trees, was examined tree by tree. Wherever possible, badly infested areas were examined twice, and sometimes three times. Every tree on which even a single scale, whether dead or alive, was found was broken down and the nurseryman required to dig it out the same day and burn it. In order to insure better results all trees and shrubs in fence corners, roadsides, and orchards in and for half a mile at least on every side of the nurseries were examined early in the spring, and if infested either required to be destroyed or well sprayed. The nurserymen have heartily co-operated in this work. Inspection, however, though of great value, is

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not meant to take the place of, but to supplement, fumigation with hydrocyanic acid gas. Each fumigation house is carefully inspected and tested by the Provincial inspector and the local inspector before the fumigation begins, and in order to be sure that the chemicals used are not adulterated, nurserymen are required to purchase them only from certain reliable firms who guarantee the purity and strength.

CONCLUSION.

We have seen that the San José Scale is a very destructive insect. The method of combating it successfully has also been described. Some may think that the amount of labor involved is great. It sometimes is, especially in neglected old orchards the first year, but it should be remembered that an old orchard may often be made the most valuable part of the whole farm. Many of the best paying orchards of to-day were neglected until a few years ago. *The steps outlined for putting them into shape for spraying for San José Scale are those that would have to be followed in renovating the orchard even were there no scale.* Of course these have to be supplemented by two later sprayings to control the various insect pests and keep off disease so that the fruit may be clean and the foliage healthy. The orchards also require either to be cultivated or fertilized, or often both, to supply plenty of food for growth. Any man who will take the trouble to combat the scale in earnest will naturally go farther and do the extra spraying and fertilizing to insure a good return for his labor. Often the first year his crop will be poor, because the trees if badly infested have been too starved and weak to produce fruit buds, but the second year he may ordinarily expect a crop. San José scale is being satisfactorily controlled all over North America to-day, and no man really interested in losing any trees by it. Many growers claim that the insect in their particular district has been more of a blessing than a curse to them, because it has shown them the value of spraying and of thoroughness.

The Oyster-Shell Scale

(*Lepidosaphes ulmi*, L.)

INTRODUCTION.—The Oyster-shell Scale is well known to nearly all the fruit-growers of Ontario, as it occurs not only in every fruit district but also in most orchards in these. Like the San José Scale, it is believed to be an imported insect. When it was introduced is unknown. It has, however, been in North America for more than 120 years. It is so widely distributed over the world to-day that the original home is uncertain. A few years ago this insect was much feared by fruit-growers, who believed it was increasing and likely to seriously injure their orchards. The methods of control then advocated were thought to be unsatisfactory, and the need of a simpler effective remedy was keenly felt. Fortunately this has been found, and has gained the confidence of the growers.

PLANTS ATTACKED.—Apples, pears, plums, cherries, currants and gooseberries are attacked, but of these apples are much worse infested than the others. Prof. Jarvis and I have found it also on rose bushes, spireas, lilacs, hawthorn, mountain ash, red-osier dogwood, black ash, white ash, prickly ash, poplar (*Populus tremuloides*), basswood, horse chestnut and mulberry. Of these, hawthorns and red-osier dogwood were the favorites, and were sometimes badly infested. There is no doubt that further search would show that the insect feeds also on many other plants in this Province. Prof. Quaintance, of the Bureau of Entomology, Washington, D.C., in Circular 121, gives a long list of plants on which the scale has been found in North America.

NATURE AND EXTENT OF THE INJURY.—Unlike the San José Scale, the Oyster-shell does not attack every part of the tree, but confines itself almost entirely to the trunk and branches, though occasionally it is found on the fruit of apple trees. Probably the reason this is not worse attacked is that nearly all the young active larvae have settled down and inserted their sucking beaks into the bark before the fruit has begun to form. The new growth on the branches, except towards its base, is also exempt for the same reason. The injury, as in the case of the San José Scale, is caused by the numerous insects with their long, hair-like beaks sucking the food out of the tender tissues beneath the bark and slowly starving the trees. An oblique-cut beneath the affected bark shows little brown areas where the scales have fed. In my experience the insect exhibits a decided preference for neglected and weakened trees, such as those we see along the roadside or in fence corners here and there over the farm, or in orchards that have been starved or weakened by winter injury. It is not at all uncommon to find the above classes of trees so badly attacked that the bark is almost concealed by the scales. Young trees as a rule seem to be worst infested. Occasionally a tree badly attacked dies, but usually they continue to live for many years in a weakened condition. The bark on these trees becomes after a few years very rough and scurvy, and even if the scale is killed does not recover its smoothness for several years. In thrifty orchards the insect is seldom very abundant, though it is usually present in moderate numbers in most of the trees unless they have been treated to destroy it. Occasional branches in these orchards may be so badly attacked as to die, but this is not very common.

I have on several occasions seen trees that were once badly infested throw off the scale in some inexplicable manner and take, as it were, a new lease of life. This, however, does not seem to happen very frequently.

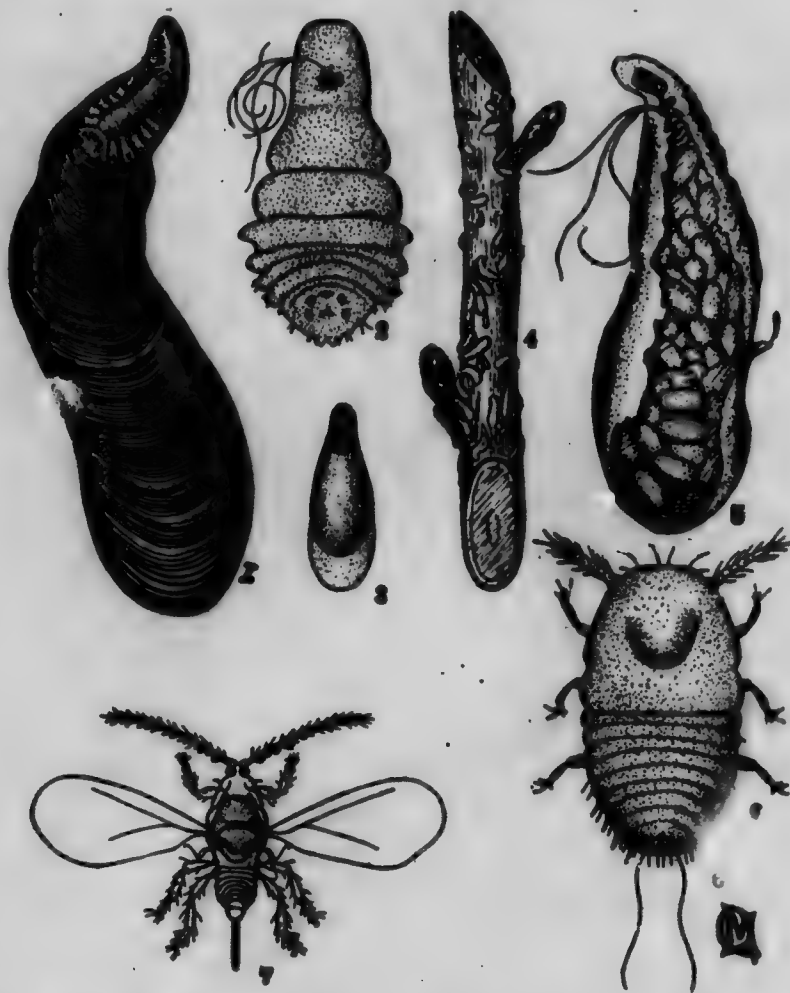


Fig. 14. Various stages of the Oyster-shell Scale: 4. The scale slightly enlarged on a twig. The little holes in the scales indicate where parasites emerged. 1. The female scale very much enlarged, showing general shape. 5. A similar scale turned over to show the eggs beneath. The shrivelled body of the female herself is beyond the eggs at the small end. 2. A female removed from beneath the scale before she has laid her eggs. Note the bristle-like mouth parts similar to those of San José Scale in fig. 4. 3. A male scale. 6. Young larva. 7. Winged male. All except No. 4 much enlarged (after San and Metcalfe).

HOW TO IDENTIFY THE OYSTER-SHELL SCALE.

REMARKS.—Fig. 14 with the description beneath it makes the appearance of the adult female scale (the only stage of the insect noticed by fruit-growers) so clear that very little further description is necessary. The insect is about $\frac{1}{6}$ of an inch long and scarcely 1-3 of this in width, is frequently curved more than shown

in the figure, especially when they are crowded together; tapers towards one end, and is brownish in color, though it usually resembles very closely the color of the bark on which it is found, so that on light-colored bark like hawthorn it is decidedly lighter in color than on the reddish-brown bark of an apple tree.

The male scales (see No. 3, Fig. 14) as shown here, and as found in nature, are like diminutive females. They are colored much the same, but are very much smaller. Usually when the bark is examined they escape notice among the other scales. They seem to be rare.

It is interesting to compare Figs. 3 and 14 and see how very different in form the San José and Oyster-shell scales are. Clearly no one need ever mistake one for the other.

LIFE HISTORY.—The Oyster-shell Scale, unlike the San José, passes the winter in the egg stage beneath the scale covering. (See No. 5, Fig. 14.) The eggs are glossy white, and may easily be seen if fresh-looking scales on a piece of bark are



Fig. 15. The little white dots are the young white or cream-colored larvae of the Oyster-shell scale just after settling down on the bark.

removed with a pin or knife over any black surface, on which they will show up clearly, as some will usually fall out during the operation. With the aid of a hand lens those left inside the scale can also be seen. There are from about 20 to 100 eggs in each scale, and about an average of 40 or 50. In Ontario the eggs hatch usually around the first of June or about the time the blossoms have fallen; sometimes it is a few days later before they are all hatched, as this continues for five days or more, depending apparently on the amount of heat; in hot weather they hatch more quickly. The little larvae that hatch from the eggs are white or cream-colored (see Fig. 15), and for a few hours after emerging they run around on the bark and then settle down and insert their long, hair-like sucking tube, which is just like that of the San José Scale (see Fig. 6), through the bark. Soon they cover themselves over with a pale, brownish, waxy covering, and later, as they continue to grow, the large, familiar brown scale is gradually formed. The female insects never move after they have once settled down, but remain under the brown covering. The males, on the contrary, when full grown, back out from under their covering as tiny two-winged little creatures (see No. 7, Fig. 14), and fertilize the

females before these are full size. This probably takes place early in July, the exact date unfortunately was not determined. In August the female has reached its full development, and its body is so distended with eggs that it occupies the whole of the cavity beneath the covering. It then begins to lay its eggs, and as it does so its body gradually gets smaller and smaller, until by the time they are all laid it is so small that it can only with difficulty be seen beneath the small end of the scale close to the eggs. The female dies very soon after laying all her eggs. There is only one brood a year in Ontario, though in counties farther south there are two broods.



Fig. 16. 1. Adult parasite (*Aphelinus mytilaspidis*) of Oyster-shell Scale. 2. Larva of parasite in scale with scale insect on one side and eggs on the other. 3. Pupa of parasite. All much enlarged, (after Sherman and Metcalfe).

RATE OF ANNUAL INCREASE.—As stated above, the average number of eggs per female is between 40 and 50. If, as in the case of the San José Scale, we allow for a mortality of about 50 per cent.—which I think is not too high for the Oyster-shell Scale, though probably much too high for the San José—there will not be more than 25 offspring from a single female in a year. The rate of increase therefore is small. Comparing this increase of 25 from one with 1,000,000 from one on the part of the San José Scale, we can easily see why the latter scale is so much more destructive and to be feared.

MEANS OF DISTRIBUTION.

The chief means of distribution for the Oyster-shell Scale, just as for the San José, is the shipment of infested nursery stock. It is also spread by the little cream-colored larvae crawling on birds, insects of various kinds, or almost any kind of moving thing that comes in contact with them, and being carried by these to other trees. As the time when larvae are active is only a few days around the first of June, compared with a long period of over three months for the San José Scale, it is clear that this latter method of distribution would not be so rapid in the case of the Oyster-shell.

NATURAL ENEMIES.—The natural enemies of the scale in Ontario are more important than those of the San José Scale. Certain Ladybird beetle adults and larvae feed to a small extent upon them, as do also a few mites; a reddish fungus disease also occasionally does some good, but the only foes of real importance are

the tiny four-winged parasites like the one shown in figure 16. These little creatures in their larval stages feed both upon the insect itself under the scale and upon the eggs, and when full grown come out from tiny round holes which they make near the centre of the scale, and which can easily be seen with a hand lens. There are several species of these parasites, but the only one I know of at present in Ontario is shown in figure 16. In some localities as high as 50 per cent. or more of the scales have these small holes, and though they do not destroy all the eggs beneath a scale they must be of considerable aid in keeping down the rate of increase.

MEANS OF CONTROL.

The lime-sulphur wash, properly applied, will readily control this scale. Two sprayings should be given for the best results, the first at the strength of 1.080 specific gravity hydrometer reading, or about one gallon of the commercial lime-sulphur diluted to ten gallons with water and applied shortly before or as the buds are bursting; the second at the strength 1.009 specific gravity, or the commercial diluted one gallon to thirty or thirty-five with water and applied just after the blossoms have fallen. Two pounds of arsenate of lead should be added to every forty gallons of the mixture for this application, as this is the proper time to spray for the Codling Moth, Plum Curculio and Lesser Apple-worm. Of these two applications the first is far the more important, but does not always give uniformly good results. Sometimes it will destroy almost all the eggs or prevent the larvae if they hatch from escaping from the covering scale, at other times a large number hatch, though most of these soon die, killed apparently by the spray mixture that remained on the tree. There is no doubt that this one application repeated each year will itself soon free the trees from the pest, but the results are accomplished more quickly by the aid of the second application at the time stated above. This will kill most of the larvae that are already hatched, and will leave the bark covered and so repulsive to any that may hatch a few days later. The great point, however, in favor of using lime-sulphur in preference to any other known remedy is that this wash not only destroys the Oyster-shell Scale, but many other things as well; for instance, the first application before or as the buds are bursting will also control San José Scale, Blister Mite, Tent Caterpillars—these must be hit soon after hatching—but also helps to ward off such diseases as Scab and Black Rot Canker. The second application, combined with the arsenate of lead, is always required to control Codling Moth, Plum Curculio, Lesser Apple Worm, Scab and Leaf Spot. For this spray lime-sulphur has proven itself even more satisfactory than Bordeaux mixture as a fungicide, because it keeps off the Scab on the fruit without causing the serious russeting and even cracking of apples commonly resulting from Bordeaux mixture. It is clear, therefore, that these two applications with these mixtures should be given even if there were no Oyster-shell or San José Scale to combat. In addition to these, our best growers give an intermediate application just before the blossoms burst, and most of them use the weak lime-sulphur here, too, along with two or three pounds of arsenate of lead. Bordeaux, however, may be used in place of the lime-sulphur, and is possibly even more effective at this stage as a fungicide. This application is important for the destruction of early-feeding caterpillars and for the control of scab.

As in the case of the San José Scale, old trees should be pruned before spraying and the rough bark scraped off. If the trees are not vigorous, a liberal dressing of barnyard manure or cultivation in May and early June will help them to recover more quickly from the effects of the scale.

